Plug and Play SCSI Specification

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Plug and Play Forum - login to CompuServe, enter 'go plugplay', leave messages in SCSI/IDE section.

SCSI BBS: 719-574-0424
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ftp site: ncrinfo.ncr.com (/pub/standards/pnpscsi directory)

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Foreword

The Plug and Play SCSI (PnP SCSI) effort was undertaken as an extension to Plug and Play ISA. Microsoft encouraged host adapter manufacturers to participate in this effort to develop an easy to use SCSI environment in the personal computer marketplace.

PnP SCSI is a profile, not a standard. PnP SCSI references the SCSI-2 standard and portions of the draft SCSI-3 standards. PnP SCSI selects specific options and features from these documents.

This specification is part of the PnP family and is designed to facilitate usage of the Small Computer System Interface (SCSI) on personal computing products. This document is an open, public specification supplementing existing SCSI specifications. This specification is intended to be platform and operating system independent.

Companies which contributed to developing the initial draft specification include: Adaptec, AT&T Global Information Solutions (formerly NCR), Digital Equipment Corporation, Future Domain, Maxtor, and Microsoft.

Introduction

This document contains a complete set of specifications required for implementing Plug and Play SCSI 1.0 systems. Future revisions are possible but are not expected to alter baseline requirements defined herein.

SCSI offers a cost-effective, high-performance interface for storage devices and permits attachment of external devices such as CD-ROMs, scanners, and printers.

SCSI is designed to accommodate a broad range of applications and performance levels. This results in multiple choices for such items as connectors, cables, termination, etc. These choices can lead to incompatibilities. This specification defines a profile for personal computing environments that eases the integration task and promotes compatibility of conforming devices. PnP SCSI systems are easier to configure because the configuration choices are simplified. Adding a PnP SCSI device to a PnP SCSI system requires no special user skills or knowledge.

PnP SCSI simplifies termination by making proper termination a side effect of configuring the system. Termination is not included within SCSI peripheral devices; thus the confusion over the presence of a terminator and the possibility of excessive terminators are eliminated.

PnP SCSI eliminates the problem of setting unique SCSI IDs through use of a protocol called SCAM, that performs an automatic ID assignment. Legacy SCSI devices are permitted to coexist with newer SCAM devices by using an ID assignment convention based on the peripheral device class.

PnP SCSI specifies the SCSI 50-position high-density shielded connector for all external connectors and requires that the cables meet the SPI draft standard. This eliminates the confusion that exists with the multiplicity of connector and cable choices.

Command set profiles are under consideration for future PnP documents.

Products conforming to the requirements herein are termed PnP SCSI.

1. Scope

This specification defines requirements for Plug and Play SCSI host adapters, cables, and peripheral devices by establishing a profile for personal computing applications. This common profile simplifies integration and configuration of SCSI systems. This specification is a profile of the SCSI-2 standard and the SCSI-3 Parallel Interface (SPI) draft standard.

2. Reference documents

Common Access Method Transport and SCSI Interface Module [X3.232-199x]
Small Computer System Interface - 2 [X3.131-1994]
SCSI-3 Parallel Interface [X3T10/855D]

The above documents are available from:

Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112-5704
Phone: (800) 854-7179 Outside USA and Canada: (303) 792-2181
FAX: (303) 792- 2192

SCSI Configured AutoMagically [X3T9.2/93-109r5] (Accepted by X3T9.2 for SPI)

The above document is available from the SCSI BBS 719-574-0424

Advanced SCSI Programming Interface

The above document is available from the Adaptec BBS 408-945-7727.

Mini-Port Driver Developer Kit
INT 13 Extensions
Virtual DMA Services

The above documents are available from Microsoft at 1-800-759-5474.

PnP BIOS Specification
PnP Option ROM specification
PnP ISA Specification

The above documents are available from the Plug and Play forum on CompuServe (Go plugplay) *.

3. Glossary and Abbreviations

3.1. Glossary

External configuration - all SCSI peripheral devices are external to the host enclosure.

Host - A personal computer system that contains a host adapter and zero or more SCSI peripheral devices.

Host adapter - either an embedded or add-in SCSI device that acts as an initiator.

Internal configuration - all SCSI peripheral devices are internal to the host enclosure.

Legacy SCSI device - an SCSI device implemented prior to this specification that does not conform to PnP SCSI.

Mixed configuration - a combination of internal and external SCSI peripheral devices.

SCSI peripheral device - an SCSI device other than a host adapter that does not include an enclosure, power supply, or external connector.

Peripheral subsystem - an enclosure that contains one or more SCSI peripheral devices.

Internal terminator - the terminator that exists within the host that terminates the internal end of the SCSI bus.

External terminator - the terminator that exists on the last peripheral subsystem that terminates the external end of the SCSI bus.

Exit-point terminator - a terminator that may be enabled or disabled which exists at the 50-position high-density connector on hosts that support a mixed configuration.

3.2. Abbreviations

ASPI - Advanced SCSI Programming Interface
BIOS - Basic Input Output System
CAM - Common Access Method
ISA - Industry Standard Architecture
PnP - Plug and Play
SCAM - SCSI Configured AutoMagically
SCSI - either SCSI-2 or SCSI-3.
SPI - SCSI-3 Parallel Interface
VDS - Virtual DMA Services

4. Conformance

Products are required to meet all applicable sections of this specification to claim conformance with PnP SCSI. Host adapters are also required to satisfy requirements of the applicable Plug and Play host bus, including ISA, PCI, PCMCIA, etc. See Appendix B: Compliance Checklist for a summary of requirements.

An exemption to section 6.3 of this specification requiring automatic switching of exit-point termination is allowed until July 1, 1994. Any PnP products using this exemption shall have the exit-point terminator configurable via a software utility.

5. Hardware

This PnP SCSI specification is intended for use with single-ended SCSI devices. All PnP SCSI devices are required to use drivers and receivers which meet the specifications defined in single-ended alternative of the SCSI-3 Parallel Interface.

All PnP SCSI devices are required to implement SCSI Bus parity as defined in the SCSI-2 standard.

6. Connectors

All hosts and SCSI peripheral subsystems are required to use the 50-position high-density shielded connector for external connections. See the SCSI-2 standard (section 5.3.2.1, shielded

connector alternative 1 - A cable). All external SCSI connectors shall display the SCSI icon (figure 1) as defined in SPI Annex F.

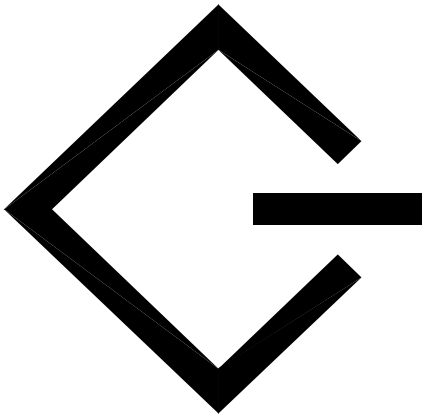

Figure 1 - SCSI Icon

The internal SCSI peripheral device connector is not specified by this document.

6.1. Cables

All cables used in PnP SCSI system must meet the cable specifications defined in clause 6 (SCSI bus cables) of the SCSI-3 Parallel Interface draft standard.

In mixed configuration systems, reliability is enhanced by the following provisions.

The SCSI bus segment in the host adapter should be of minimal length and capacitance. Where significant length is unavoidable, the bus layout on the board should follow transmission line principles and SPI impedance requirements.

The overall length of the internal bus segment should be minimized. The internal bus is either a SPI compliant backplane or a SPI compliant ribbon cable (examples: 3M 3801 .050 pitch 26 AWG PVC dielectric--89 ohms, or 3M 3749 .025 pitch 30 AWG TPE dielectric--85 ohms or equivalent).

> Note: Conventional ribbon cable (.050 pitch, 28 AWG, PVC dielectric--108 ohms) generally will work in internal configuration (only) implementations, even though it is not compliant with the SPI impedance requirements.

6.2. Terminator requirements

This section defines the requirements of the terminator and terminator power. Section 7 defines the location of terminators in system configurations.

All terminators in PnP SCSI systems shall conform to the terminator requirements in the SCSI-3 Parallel Interface document. The terminators shall operate correctly over a TERMPWR voltage range of 4.0-5.25 Vdc. Regulated terminators are required. These are often referred to as alternative 2 or active terminators.

The host and the peripheral sub-system shall provide terminator power (TERMPWR) to the SCSI bus. All terminators must be powered from the TERMPWR line(s) in the SCSI bus.

Note - Exceptions may be necessary for battery operated devices and PCMCIA PC-Cards.

Devices providing TERMPWR must provide a self-resetting device (e.g. positive-temperature-coefficient or circuit breaker device) to limit the maximum amount of current sourced instead of a fuse. Such a device opens the circuit when excessive current is drawn and closes the circuit when the device resets.

6.3. Device Power

Only terminators may draw power from TERMPWR. SCSI devices that are powered off should not sink current from the SCSI bus.

Power management functions are outside the scope of this document.

6.4. SCSI ID assignment

Each device on the SCSI bus requires a unique SCSI identifier or ID for that bus. ID conflicts, indeterminate switch settings, and location of ID switches on the devices complicate the process of configuring the SCSI bus. An automated SCSI ID assignment technique is the required solution to the problem of users inadvertently assigning the same ID to multiple devices on the same bus.

6.4.1. Automatic SCSI ID assignment

The X3T9.2 (now X3T10) committee has voted to include a protocol, SCSI Configured AutoMagically (SCAM), into the SCSI-3 Parallel Interface draft standard. SCAM automatically assigns device ID's. All PnP SCSI devices are required to conform to level 1 of this document and level 2 conformance is recommended.

The SCAM protocol is designed so that legacy devices can be detected and used. If more than one legacy device is present, the user must ensure that they do not have SCSI ID conflicts. Devices that support SCAM function correctly in legacy systems.

6.4.2. Default SCSI ID's

It is important for SCAM devices to have a default ID setting in case they are used on a SCSI bus that does not use a SCAM master host adapter. Therefore, default IDs listed in table 1 are recommended settings for all PnP SCSI devices as shipped from the factory. Provision may be given to the user to change the default ID to control configuration.

Table 1 - As shipped default SCSI ID assignment

SCSI ID	SCSI Default ID
7	Host Adapter
6	Magnetic Disk Drive
5	
4	Tape or R/W Optical
3	CD-ROM
2	Scanner/Printer
1	
0	

SCSI IDs 5, 1, and 0, are used during system configuration for additional devices.

6.4.3. SCAM ID assignment algorithm

SCAM masters should assign the same SCSI ID to SCAM devices as previously assigned to the SCAM device to ensure consistent ID assignment. If the SCAM master is unable to maintain a non-volatile device table or there has been no previous ID assignment, then the following algorithm should be used (see Appendix C for examples):

> During the isolation stage, the SCAM master isolates each SCAM device one at a time and stores the device's Default ID. The 5-bit ID field within the Type Code contains the device's Default ID. The SCAM master shall assign the SCAM device a Soft ID after its isolation stage is completed and before proceeding to isolate the next SCAM device.
>
> The SCAM master shall assign Soft IDs that are available and not already used by any other device on the bus. The first choice shall be the device's Default ID. Otherwise, the choice shall be the next smaller ID that is available. If ID zero is not available, the SCAM master shall assign the highest available ID. If no ID is available, no Soft ID shall be assigned to the device.

7. System configurations

Plug and Play requirements exist for three possible configurations:

a) Internal configuration - all SCSI peripheral devices are internal to the host enclosure.
b) External configuration - all SCSI peripheral devices are external to the host enclosure.
c) Mixed configuration - a combination of internal and external SCSI peripheral devices.

Each of these configurations exist for two design alternatives: add-in SCSI and motherboard SCSI. The term host adapter is used to refer to either the SCSI add-in card for the add-in SCSI design alternative or the SCSI logic within the host for the motherboard design alternative.

PnP SCSI host adapters that support a mixed configuration shall have an automatic switchable terminator at the exit point.

PnP SCSI peripheral devices shall not terminate the SCSI bus.

PnP SCSI peripheral subsystems attached to the SCSI bus shall be terminated by installing an external terminator into the remaining open connector on the last peripheral subsystem on the bus.

7.1. Add-in SCSI Design Alternative

The add-in SCSI alternative for the internal, external, and mixed configurations is shown in figure 2.

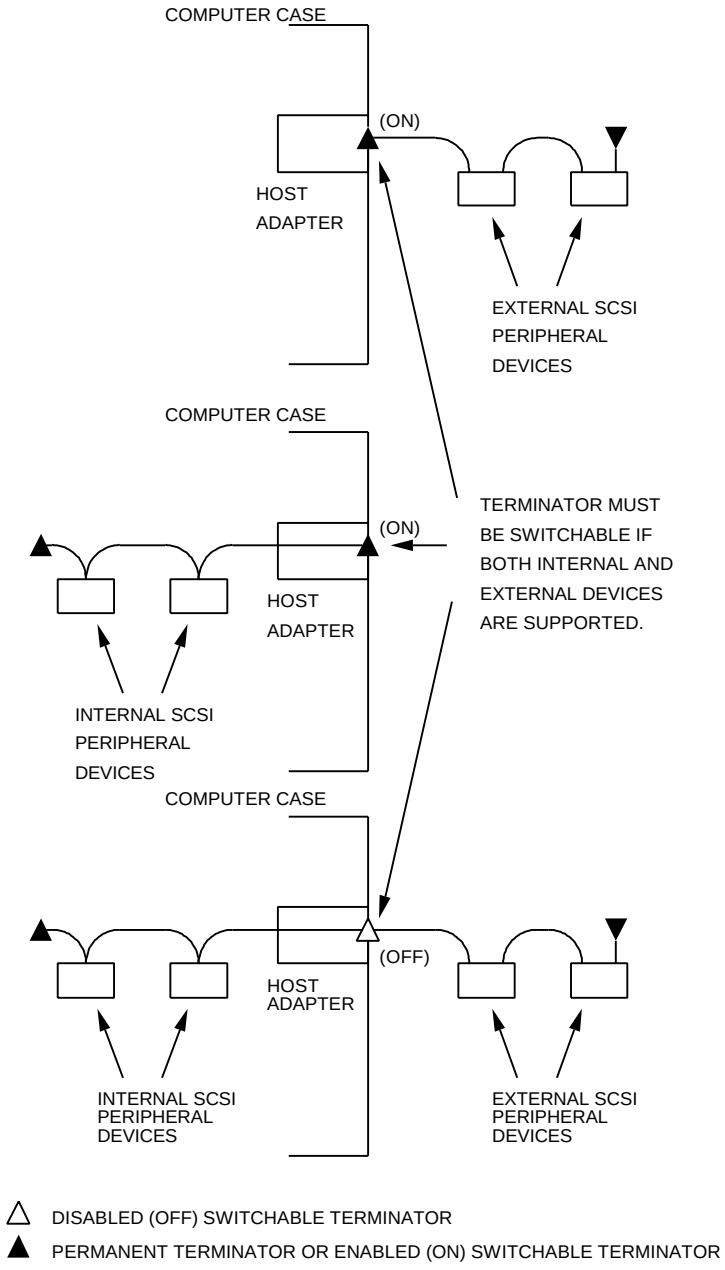

Figure 2 - Add-in SCSI Design

In the internal configuration the host adapter and internal terminator supply the necessary termination.

The internal SCSI bus is routed as necessary within the PC, complying to the rules in SPI, to one or more SCSI devices. The end of the internal SCSI bus ends with an internal terminator.

Keyed connectors are required on the host adapter and the cables to ensure that the cable is plugged in correctly (not reversed or shifted). Systems with backplane SCSI buses are required to meet the electrical requirements of the SCSI-3 Parallel Interface document, particularly with respect to characteristic impedance.

In the external configuration the internal and external terminator supply the necessary termination.

Peripheral subsystems are required to provide two 50-position high-density shielded connectors on the enclosure. The SCSI bus internal to the enclosure is routed from one external SCSI connector to the SCSI device(s) within the enclosure and then to the second external SCSI device connector.

One external terminator must be installed on the last SCSI peripheral subsystem. The user may purchase the external terminator and cable when installing the first SCSI peripheral subsystem.

In mixed configurations the exit-point terminator is automatically enabled or disabled to correctly terminate the SCSI bus based on detection of the configuration. This is accomplished through mechanical or electronic detection of the attached cable or electronic detection of attached SCSI device(s).

> Note - A switchable terminator may be employed to serve as either the internal terminator (external-only configuration) or the host adapter terminator (internal-only configuration). In the mixed configuration, the switchable terminator must be disabled whenever both internal or external cables are attached or both internal and external SCSI devices are present.

7.2. Motherboard SCSI Design Alternative

The motherboard SCSI alternative for the internal, external and mixed configurations is shown in figure 3.

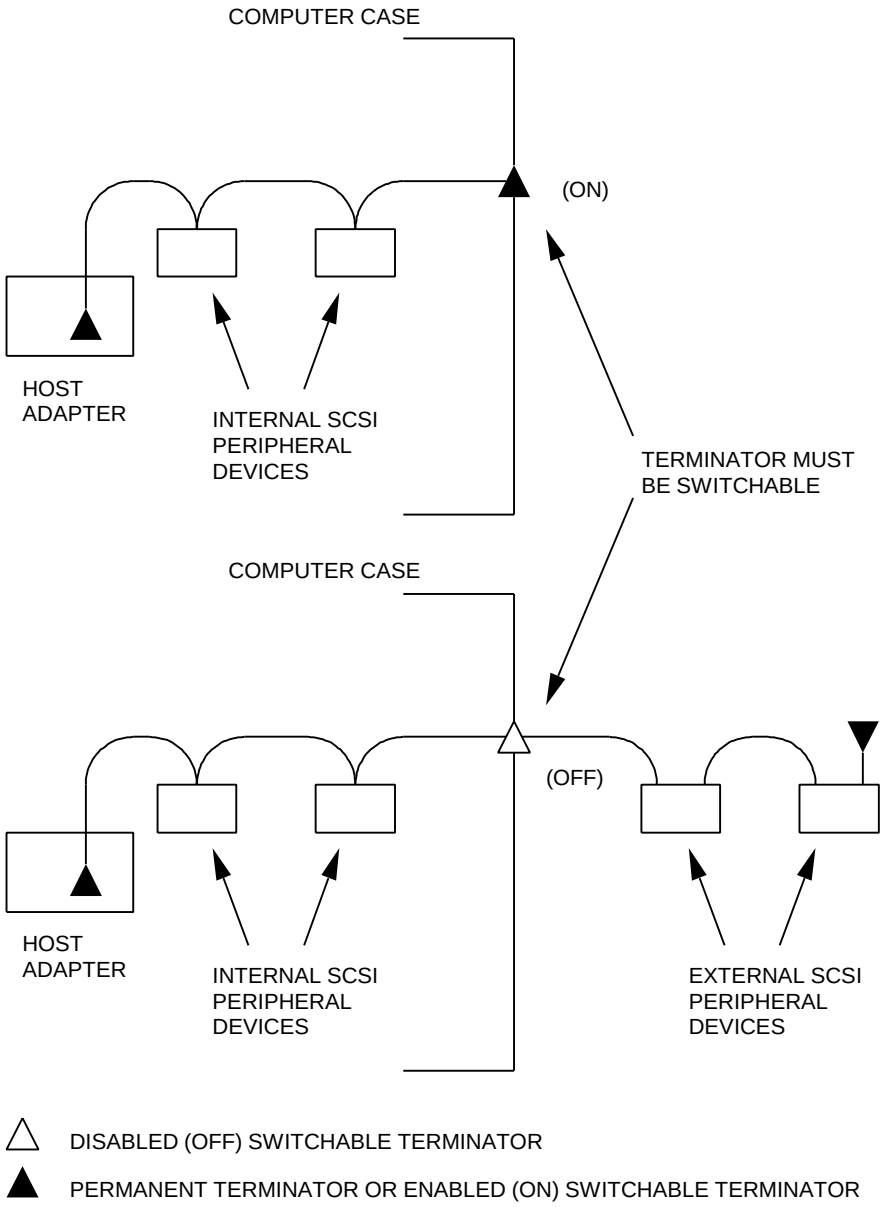

Figure 3 - Motherboard SCSI Design

In the internal configuration the host adapter and internal terminator supply the necessary termination.

The internal SCSI bus is routed as necessary within the PC, complying to the rules in SPI, to one or more SCSI devices. The end of the internal SCSI bus ends with an internal terminator.

If cables are employed, keyed connectors are required on the motherboard and the cables to ensure that the cable is plugged in correctly (not reversed or shifted). Systems with backplane SCSI buses are required to meet the electrical requirements of the SCSI-3 Parallel Interface document, particularly with respect to characteristic impedance.

In the external configuration the internal and external terminator supply the necessary termination.

Peripheral subsystems are required to provide two 50-position high-density shielded connectors on the enclosure. The SCSI bus internal to the enclosure is routed from one external SCSI connector to the SCSI device(s) within the enclosure and then to the second external SCSI device connector.

One external terminator must be installed on the last SCSI peripheral subsystem. The user may purchase the external terminator and cable when installing the first SCSI peripheral subsystem.

In systems that support mixed configurations, the exit-point terminator is automatically enabled or disabled to correctly terminate the SCSI bus. This is accomplished through mechanical or electronic detection of the attached cable or electronic detection of attached SCSI device(s).

7.3. Mixed configuration Example

Figure 4 illustrates a mixed configuration with an add-in SCSI design alternative. This figure is provided as a reference and should not be construed as a specification of requirements. The internal terminator should be as close as possible to the last internal SCSI peripheral device; the distance in the figure is exaggerated for clarity. The system combines internal and external devices on the same SCSI bus.

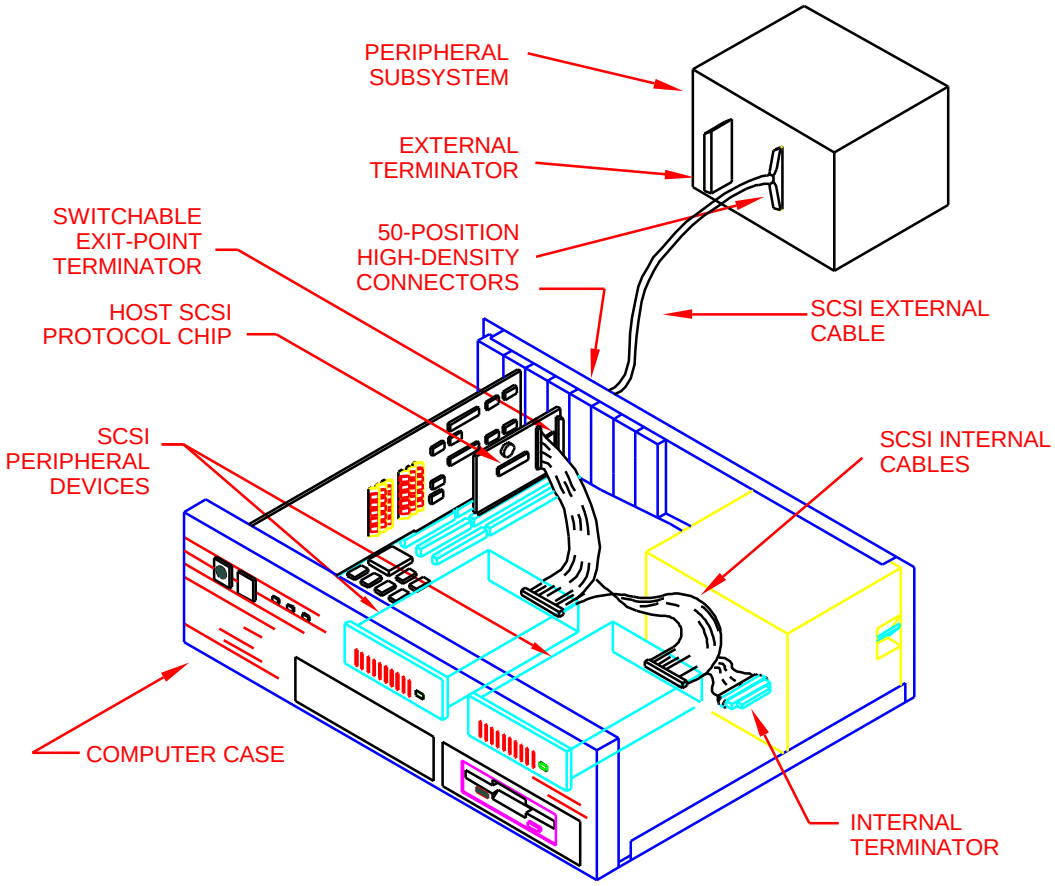

Figure 4 - Mixed Configuration Example

8. X86 Software Issues

The following subsections describe software issues specific to X86 architecture DOS-based systems when developing a plug and play system.

8.1. Geometry translation

In a DOS environment host adapter option ROM's are required to support the logical block addressing as defined by the INT 13h Extensions document. For backward compatibility, SCSI option ROM's are required to support the current INT 13h functions as well. To determine the geometry for INT 13h function 08h, these option ROM's read the partition table from the disk at LBA 0 and if it exists as determined by the 55AAh signature at offset 1FEh, use the existing geometry to calculate the Cylinder-Head-Sector (CHS) values. Appendix A provides an example of how to determine the geometry. If the partition table does not exist, SCSI option ROM's may use any algorithm to set the CHS values.

9. Generic Software Issues

There are several generic software issues related to designing a plug and play system. Some of these are addressed in the subsections that follow. One issue that is not addressed is command sets for the specific device types. Command set profiles are under consideration for future PnP documents to insure minimum device functionality and device driver interoperability.

9.1. READ CAPACITY command

A direct-access device is required to return the actual number of user-accessible logical blocks on the drive. This value does not include the sectors reserved for defect mapping.

9.2. INQUIRY command

All devices are required to return INQUIRY data in a timely manner without excessive delays. This enables a SCSI host to scan the SCSI bus and boot without significant delays.

> NOTE - Historically, some SCSI devices when first powered up performed operations that delayed their response to selection for lengthy mechanical actions and device initialization (e.g., rewinding an inserted tape, spinning up the medium, etc.). Excessive delays are not acceptable in a PnP SCSI environment.

9.3. Synchronous negotiation

The synchronous negotiation protocol is required to be implemented as defined in SCSI-2. If the device supports only asynchronous data transfers it must respond with a MESSAGE REJECT message to a SYNCHRONOUS DATA TRANSFER REQUEST message and continue in asynchronous data transfer mode.

9.4. Virtual DMA services (VDS)

PnP SCSI host adapters that support bus-mastering are required to support Virtual DMA Services (VDS) in the host adapter option ROM. VDS solves the problem of mapping linear addresses (segment:offset) into physical addresses. VDS is not applicable to host adapters that do not use bus-mastering.

9.5. Device driver architecture

There are two primary device driver protocols in use today. These are ASPI and CAM. Windows NT and future windows OS's use their own SCSI protocol which is referred to as the Miniport interface. It is recommended that vendors of host adapters supply drivers compatible with one or more of these layered driver architectures.

9.6. Software configuration

All PnP host adapter configuration parameters are required to be configurable with a software utility. The PnP ISA specification provides one example of host parameters that are configurable. SCSI parameters that are configurable are required to be controlled with a software utility (e.g., enable/disable synchronous operation).

9.7. Boot considerations

PnP hosts are required to assign SCSI IDs in a consistent and repeatable manner through power cycles or resets using the algorithm specified in section 6.4.3, so long as the SCSI bus configuration remains static. Non-static environments, such as physically removing or powering down a device prior to a boot cycle, may affect drive ID assignment, which can lead to no-boot situations. Resolution of this issue is beyond the scope of this specification. The issue requires system level solutions possibly affecting the BIOS and the operating system.

The long-term solution to non-static configuration environments is PnP system extensions enabling the end user to select the boot device on multiple-device systems. Until such extensions are defined and implemented, the no-boot condition, which can occur in legacy systems today, may also occur in PnP systems. In both cases, the correct boot device may be recognized by adjusting the SCSI IDs through host adapter utilities or changing the device default ID. This is an interim solution which will be replaced when a broader PnP system solution is defined.

APPENDIX A - CHS mapping

Existing operating systems use a Cylinder-Head-Sector (CHS) mapping for "talking" to hard disk drives via INT 13h. These CHS values limit the maximum number of blocks on a disk to 1024 * 255 * 63 which is slightly less than eight Gigabytes. To overcome this, new operating systems have defined new partition table system type values. These values will be used for partition entries whose limits exceed the CHS mapping capabilities.

The two new system types are 0Eh for primary partitions and 0Fh for extended partitions meeting the criteria above. These entries will have CHS values of 0Fh and will use the LBA starting field (offset 08h in the partition entry) and the Length field (offset 0Ch) to describe the partition. Access to these partitions will be by the INT 13h extensions as defined by Microsoft. The following routine is pseudo-code for detecting an existing partition and calculating geometry using this information.

Partition table entry format

Offset	Description	Variable
00h	Boot indicator	
01h	Start Head	StartHead
02h	Start Sector/Cylinder	StartSector
03h	Start Cylinder (low 8 bits)	StartCylinder
04h	System type	SystemType
05h	Ending Head	EndHead
06h	Ending Sector/Cylinder	EndSector
07h	Ending Cylinder (low 8 bits)	EndCylinder
08h	Starting sector	StartingSector
0Ch	Number of sectors in partition	NumSectors

Some other variables	Description
Sectors	Sector value for CHS result
Heads	Head value for CHS result
Cylinders	Cylinder value for CHS result
CHS	Short for StartHead, StartSector, and StartCylinder
capacity	Value returned from SCSI read capacity

```
void  GetCHS( void )
{
   ulong  logical_end;
   ushort Sectors;
   ushort Heads;
   ushort Cylinders;


For each drive
   Read Boot sector
   Validate Sector Signature (55AAh)
   Find Partition with largest logical start cylinder
      If no partitions found
         Use your own geometry routine
         exit
```

```
    if ((CHS == FF) || (SystemType == 0x0E) || (SystemType == 0x0F))
    {
        /* No Geometry is needed, use INT 13h Extensions */
        exit;
    }
    else
    {
        Sectors = EndSector;
        Heads = EndHead + 1;
        logical_end = (EndCylinder * Heads * Sectors) +
                    (EndHead * Sectors) + Sectors;

        if (logical_end != StartingSector + NumSectors)
        {
            /* use your own geometry routine */
            exit;
        }

        Cylinders = capacity / (Heads * Sectors);
    }

    /* Now use the calculated Cylinders, Sectors, and Heads values. */
}
```

APPENDIX B - Checklist of compliance requirements

Peripheral Subsystem Requirements

Hardware Design

____ 1. Devices within peripheral subsystems shall not terminate the SCSI bus.
____ 2. Provides two 50-conductor high-density SCSI connectors on the external device enclosure with visible SCSI icons near the connectors.
____ 3. Supplies terminator power to the SCSI bus with a self resetting current limit device.
____ 4. Provide labeled manual SCSI ID switches for use with non PnP master host connections. Note: This item is recommended for backward compatibility and is not a requirement for full PnP SCSI systems.
____ 5. Ship with default SCSI ID per Table 1.

Software Design

____ 1. Support SCAM level 1 slave protocol to request automatic SCSI ID assignment.
____ 2. Support the full PnP SCSI command profile if and when defined (CD ROM definition in process)
____ 3. Direct access devices return the actual number of user accessible logical blocks in response to the Read Capacity command.
____ 4. All peripherals support Synchronous Negotiation protocol to avoid hanging the bus.
____ 5. All peripherals support the SCSI INQUIRY command without significant delays.

Add-in Host Adapter Requirements

Hardware Design

____ 1. ISA adapters are required to meet the PnP ISA specification.
  1.1 Implement isolation circuit for unique card identification.
  1.2 Identify resource requirements (IRQ, DMA, Memory and I/O space) in on board registers.
  1.3 Provide software programmable resource options.
____ 2. Use a 50-position high-density connector for external SCSI connections with a visible SCSI icon near the connector.
____ 3. Supplies terminator power to the SCSI bus with a self resetting current limit device.
____ 4. Supplies regulated termination:
  4.1 For one end of the SCSI bus for internal only or external only SCSI chains.
  4.2 Only if switchable terminator is at one end of the bus.

Software Design

____ 1. Implement SCAM level 1 master protocol to automatically assign SCSI IDs.
____ 2. Adapter option ROM requirements:
  2.1 INT 13h BIOS extensions including logical block addressing for consistent geometry translation.
____ 3. Implement PnP device drivers.

System Requirements

____ 1. PnP SCSI subsystems use PnP compliant host adapters and peripheral subsystems.
____ 2. All PnP devices implement SCSI Bus parity.
____ 3. PnP SCSI subsystems use single-ended electrical interface.
____ 4. External cable assemblies meet SPI electrical characteristics.

____ 5. All terminators used in the system configuration are regulated and meet SPI requirements.

____ 6. The host and all Peripheral Subsystems supply terminator power to the SCSI bus with a self resetting current limit device - not fuses.

____ 7. If there is an internal SCSI bus, it must be terminated correctly:

- 7.1 An internal terminator is located at one end of the internal SCSI bus.
- 7.2 A second internal terminator / exit point terminator is located at the other end of the internal SCSI bus
- 7.3 Effective 7-1-94, systems which support mixed SCSI configurations (both internal and external buses) must automatically disable the exit-point terminator when an external cable is attached.

APPENDIX C - SCSI ID Assignment Examples

The following scenarios show example SCAM Soft ID assignments (see 6.4.3). In all scenarios it is assumed that the host adapter has a Hard ID of 7.

SCENARIO 1: Four Devices:
- No Hard IDs
- Four SCAM devices; Default IDs 6,6,5,4.

Isolation Sequence	Requested Default ID	Assigned Soft ID
1	6	6
2	4	4
3	6	5
4	5	3

SCENARIO 2: Four Devices:
- No Hard IDs
- Four SCAM devices; Default IDs 6,6,5,4.

Isolation Sequence	Requested Default ID	Assigned Soft ID
1	5	5
2	4	4
3	6	6
4	6	3

SCENARIO 3: Four Devices:
- No Hard IDs
- Four SCAM devices; Default IDs 6,1,1,0.

Isolation Sequence	Requested Default ID	Assigned Soft ID
1	1	1
2	1	0
3	0	6
4	6	5

SCENARIO 4: Four Devices:
- Two Hard IDs, 6,4
- Two SCAM devices; Default IDs 6,6.

Isolation Sequence	Requested Default ID	Assigned Soft ID
1	6	5
2	6	3

SCENARIO 5: Four Devices:
- Two Hard IDs, 6,0
- Two SCAM devices; Default IDs 6,0.

Isolation Sequence	Requested Default ID	Assigned Soft ID
1	0	5
2	6	4

SCENARIO 6: Four Devices:
- Two Hard IDs, 6,0
- Two SCAM devices; Default IDs 0,0.

Isolation Sequence	Requested Default ID	Assigned Soft ID
1	0	5
2	0	4

SCENARIO 7: Eight Devices:
- Two Hard IDs, 6,0
- Six SCAM devices; Default IDs 6,6,6,6,6,6.

Isolation Sequence	Requested Default ID	Assigned Soft ID
1	6	5
2	6	4
3	6	3
4	6	2
5	6	1
6	6	unassigned

Scenarios 8 and 9 illustrate that adding or removing SCSI devices does not impair the assignment of unique SCSI IDs through the SCAM protocol. SCSI ID conflicts are avoided, however SCSI IDs may change after the re-configuration. In these examples, the SCAM Devices are assumed to use SCAM strings of 'Device C', 'Device D', etc.

The following scenario illustrates the effect of adding and removing devices to a SCSI bus using a host adapter that does not save configuration information in nonvolatile memory.

SCENARIO 8: Initial Configuration of four Devices:
- Two Hard IDs, 6 (Device A), 4 (Device B)
- Two SCAM devices; Default IDs 6 (Device C), 6 (Device D).

Isolation Sequence	Requested Default ID	Assigned Soft ID	Hard ID	Device
none	none		6	A
none	none		4	B
1	6	5		D
2	6	3		C

- Add one Hard ID device 3 (Device E)
- Add one SCAM device with default ID 6 (Device F)

Isolation Sequence	Requested Default ID	Assigned Soft ID	Hard ID	Device
none	none		6	A
none	none		4	B
none	none		3	E
1	6	5		F
2	6	2		D
3	6	1		C

- Delete one Hard ID device 4 (Device B)
- Delete one SCAM device with default ID 6 (Device D)

Isolation Sequence	Requested Default ID	Assigned Soft ID	Hard ID	Device
none	none		6	A
none	none		3	E
1	6	5		F
2	6	4		C

The following scenario illustrates the effect of adding and removing devices to a SCSI bus using a host adapter that saves configuration information in nonvolatile memory.

SCENARIO 9: Initial Configuration of four Devices:

- Two Hard IDs, 6 (Device A), 4 (Device B)
- Two SCAM devices; Default IDs 6 (Device C), 6 (Device D).

Isolation Sequence	Requested Default ID	Assigned Soft ID	Hard ID	Device
none	none		6	A
none	none		4	B
1	6	5		D
2	6	3		C

- Add one Hard ID device 3 (Device E)
- Add one SCAM device with default ID 6 (Device F)

Isolation Sequence	Requested Default ID	Assigned Soft ID	Hard ID	Device
none	none		6	A
none	none		4	B
none	none		3	E
1	6	2		F
2	6	5		D
3	6	1		C

Note that device C had to be moved from ID 3 because a Hard ID device was added with ID 3.

- Delete one Hard ID device 4 (Device B)
- Delete one SCAM device with default ID 6 (Device D)

Isolation Sequence	Requested Default ID	Assigned Soft ID	Hard ID	Device
none	none		6	A
none	none		3	E

1	6	2	F
2	6	1	C

No IDs were moved from the previous case.